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(54) **SYSTEM AND METHOD FOR CACHE MANAGEMENT**

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G06F 17/30	(2006.01)

(52) **U.S. Cl.**
CPC ***G06F 12/08*** (2013.01); ***G06F 3/06*** (2013.01); *G06F 17/30* (2013.01)

(58) **Field of Classification Search**
CPC G06F 12/08
USPC 711/1–200
See application file for complete search history.

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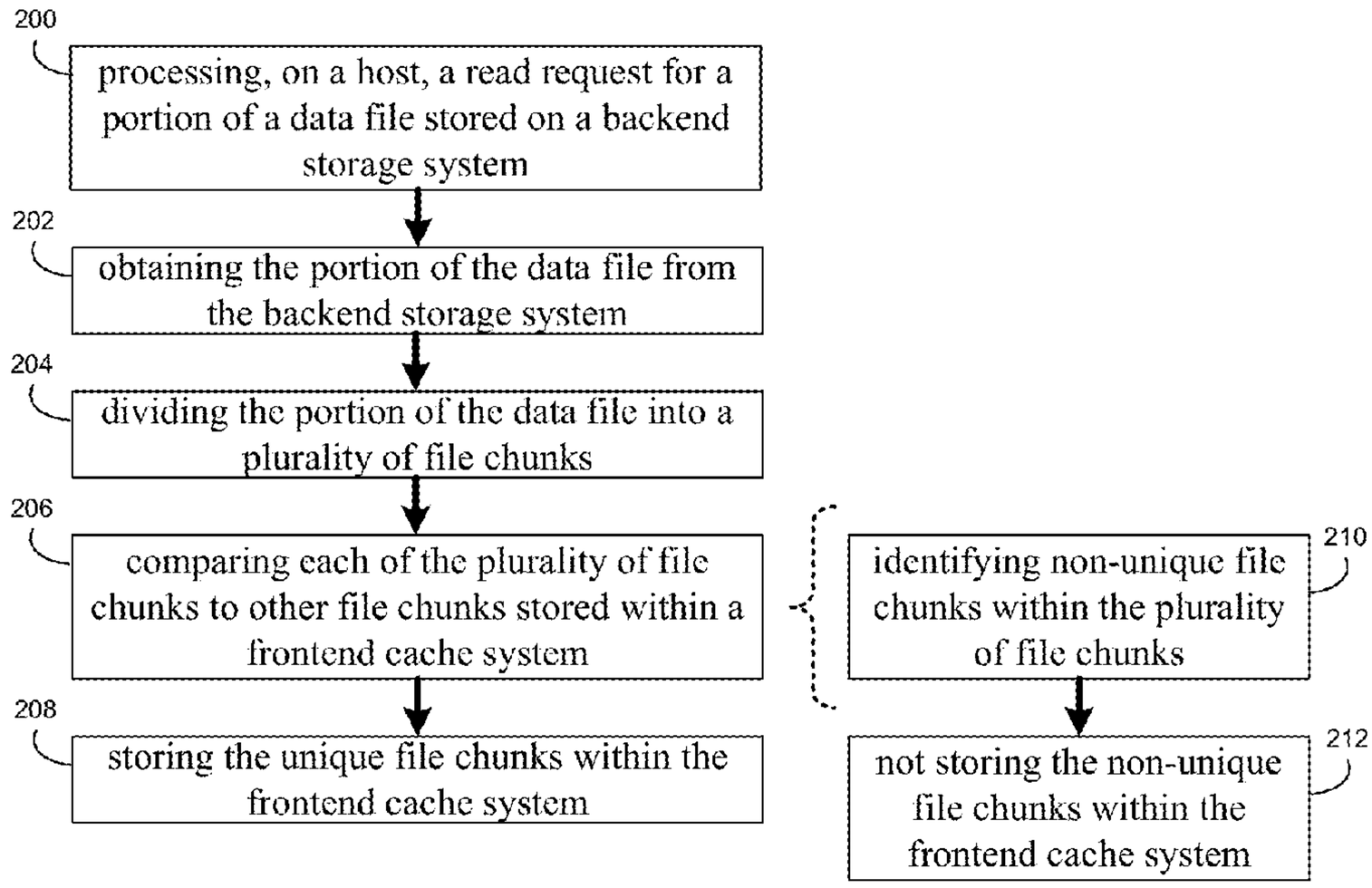
(57) **ABSTRACT**

A method, computer program product, and computing system for processing, on a host, a read request for a portion of a data file stored on a backend storage system. The portion of the data file is obtained from the backend storage system. The portion of the data file is divided into a plurality of file chunks based, at least in part, upon a file type. Each of the plurality of file chunks is compared to other file chunks stored within a frontend cache system associated with the host to identify unique file chunks within the plurality of file chunks. The unique file chunks are stored within the frontend cache system.

24 Claims, 3 Drawing Sheets



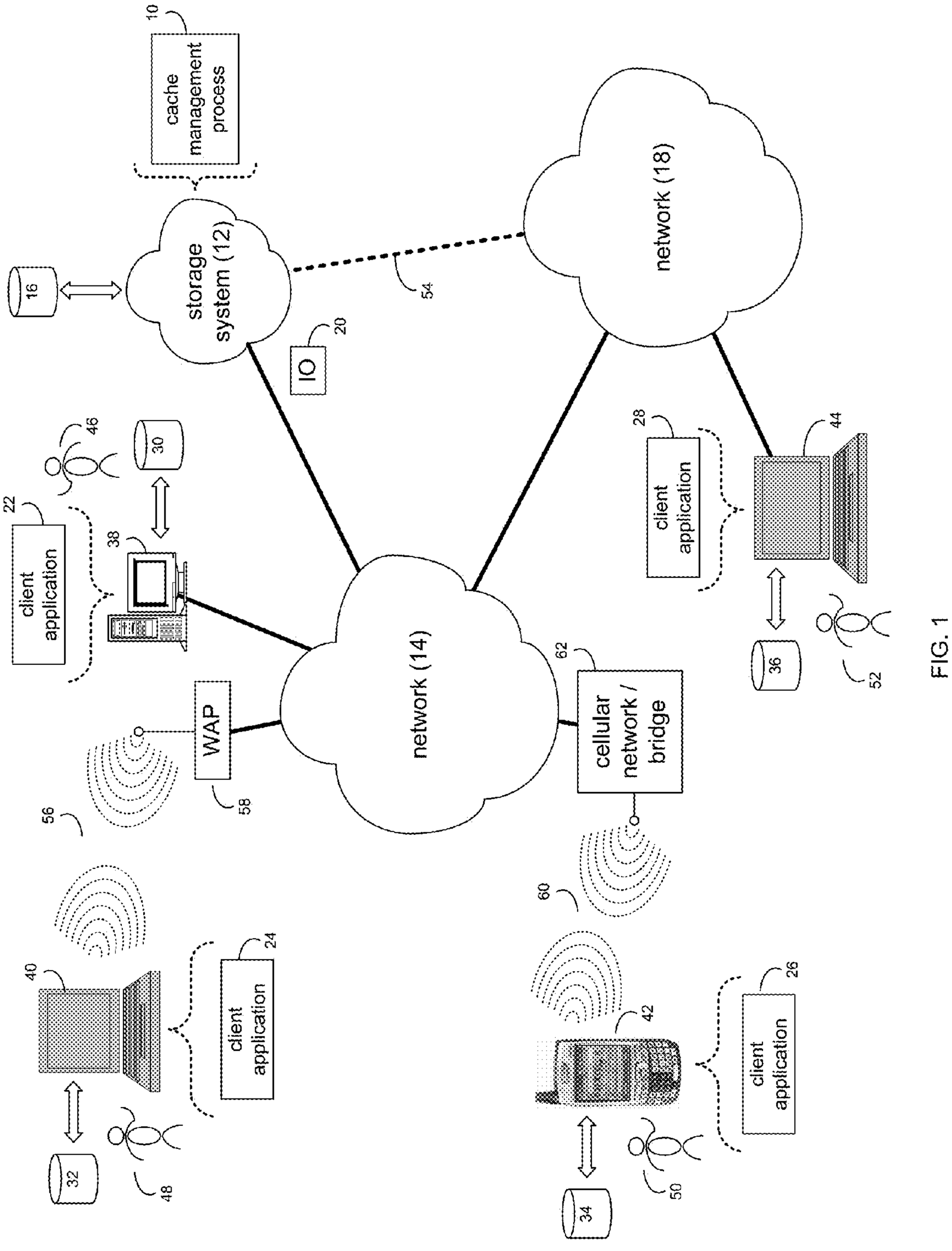

10
cache management process
network (18)
storage system (12)
16
54
IO
20
network (14)
WAP
58
56
cellular network / bridge
62
60
22
client application
38
46
30
28
client application
44
36
52
40
client application
24
32
48
42
client application
26
34
50

FIG. 1

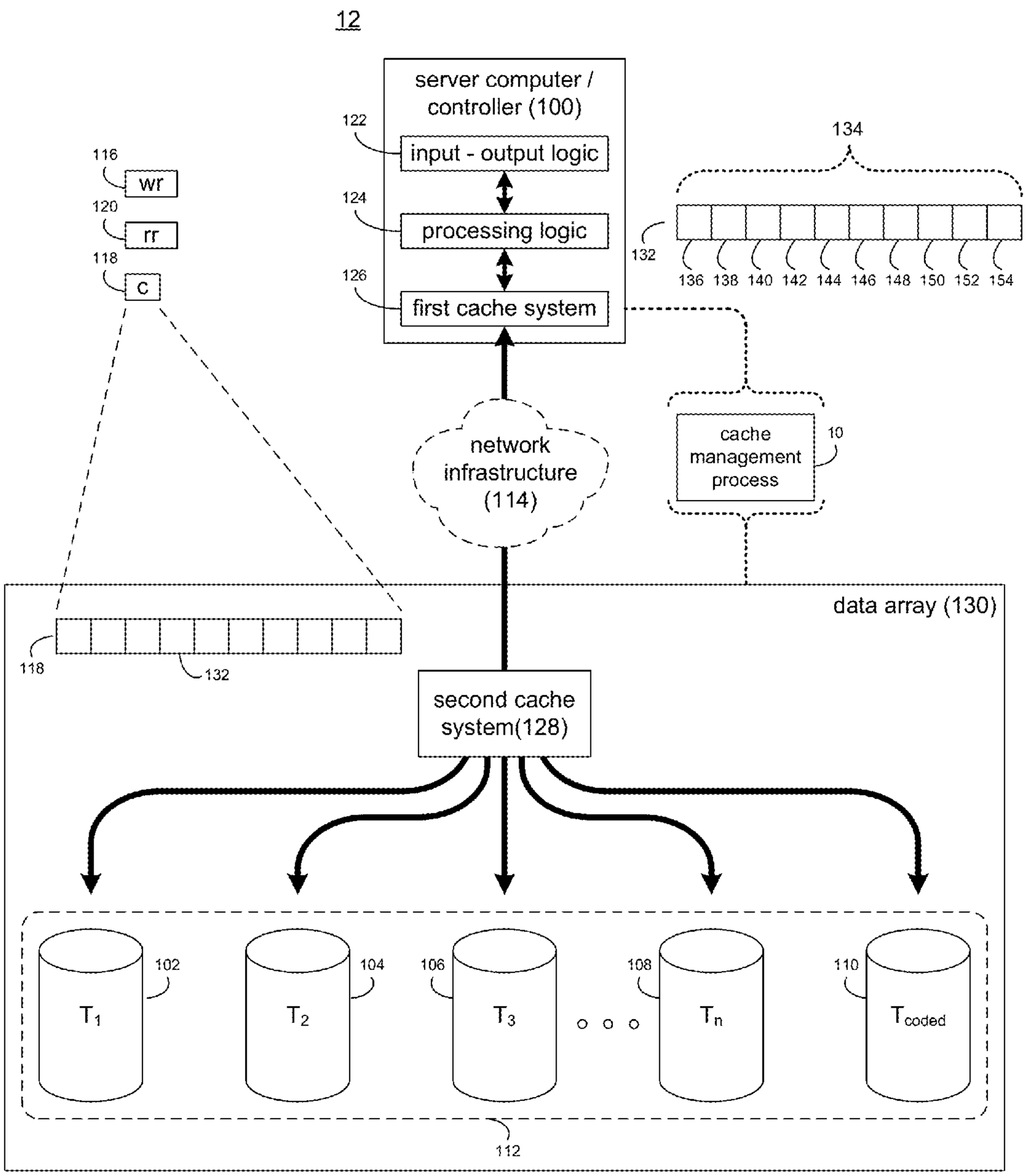

12
server computer / controller (100)
122
input - output logic
124
processing logic
126
first cache system
134
132
136 138 140 142 144 146 148 150 152 154
116
wr
120
rr
118
c
network infrastructure (114)
cache management process
10
data array (130)
118
132
second cache system(128)
102
104
106
108
110
T1
T2
T3
Tn
Tcoded
112

FIG. 2

10

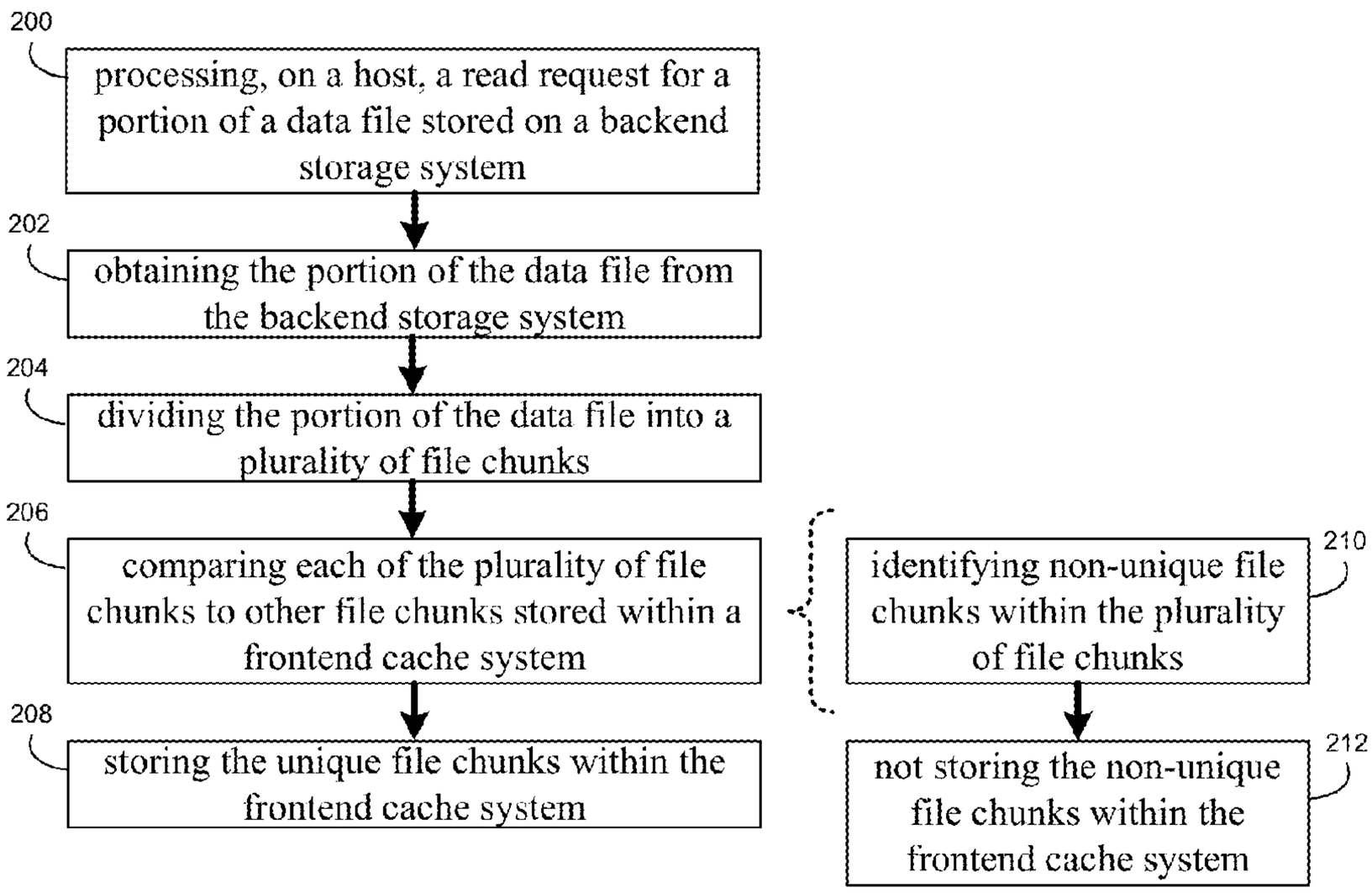

200
processing, on a host, a read request for a portion of a data file stored on a backend storage system
202
obtaining the portion of the data file from the backend storage system
204
dividing the portion of the data file into a plurality of file chunks
206
comparing each of the plurality of file chunks to other file chunks stored within a frontend cache system
208
storing the unique file chunks within the frontend cache system
210
identifying non-unique file chunks within the plurality of file chunks
212
not storing the non-unique file chunks within the frontend cache system

FIG. 3

SYSTEM AND METHOD FOR CACHE MANAGEMENT

TECHNICAL FIELD

This disclosure relates to cache systems and, more particularly, to systems and methods for cache deduplication.

BACKGROUND

Storing and safeguarding electronic content is of paramount importance in modern business. Accordingly, various systems may be employed to protect such electronic content.

The use of solid-state storage devices is increasing in popularity. A solid state storage device is a content storage device that uses solid-state memory to store persistent content. A solid-state storage device may emulate (and therefore replace) a conventional hard disk drive. Additionally/alternatively, a solid state storage device may be used within a cache memory system. With no moving parts, a solid-state storage device largely eliminates (or greatly reduces) seek time, latency and other electromechanical delays and failures associated with a conventional hard disk drive.

SUMMARY OF DISCLOSURE

In a first implementation, a computer-implemented method includes processing, on a host, a read request for a portion of a data file stored on a backend storage system. The portion of the data file is obtained from the backend storage system. The portion of the data file is divided into a plurality of file chunks based, at least in part, upon a file type. Each of the plurality of file chunks is compared to other file chunks stored within a frontend cache system associated with the host to identify unique file chunks within the plurality of file chunks. The unique file chunks are stored within the frontend cache system.

One or more of the following features may be included. Comparing each of the plurality of file chunks to other file chunks stored within the frontend cache system may include identifying non-unique file chunks within the plurality of file chunks. The non-unique file chunks may not be stored within the frontend cache system. The portion of the data file may be a complete data file. The plurality of file chunks may have a common length and may be aligned. The plurality of file chunks may have differing lengths. The backend storage system may include a data array.

Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm. Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file structure.

In another implementation, a computer program product resides on a computer readable medium that has a plurality of instructions stored on it. When executed by a processor, the instructions cause the processor to perform operations including processing, on a host, a read request for a portion of a data file stored on a backend storage system. The portion of the data file is obtained from the backend storage system. The portion of the data file is divided into a plurality of file chunks based, at least in part, upon a file type. Each of the plurality of file chunks is compared to other file chunks stored within a frontend cache system associated with the host to identify unique file chunks within the plurality of file chunks. The unique file chunks are stored within the frontend cache system.

One or more of the following features may be included. Comparing each of the plurality of file chunks to other file chunks stored within the frontend cache system may include identifying non-unique file chunks within the plurality of file chunks. The non-unique file chunks may not be stored within the frontend cache system. The portion of the data file may be a complete data file. The plurality of file chunks may have a common length and may be aligned. The plurality of file chunks may have differing lengths. The backend storage system may include a data array.

Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm. Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file structure.

In another implementation, a computing system includes at least one processor and at least one memory architecture coupled with the at least one processor, wherein the computing system is configured to perform operations including processing, on a host, a read request for a portion of a data file stored on a backend storage system. The portion of the data file is obtained from the backend storage system. The portion of the data file is divided into a plurality of file chunks based, at least in part, upon a file type. Each of the plurality of file chunks is compared to other file chunks stored within a frontend cache system associated with the host to identify unique file chunks within the plurality of file chunks. The unique file chunks are stored within the frontend cache system.

One or more of the following features may be included. Comparing each of the plurality of file chunks to other file chunks stored within the frontend cache system may include identifying non-unique file chunks within the plurality of file chunks. The non-unique file chunks may not be stored within the frontend cache system. The portion of the data file may be a complete data file. The plurality of file chunks may have a common length and may be aligned. The plurality of file chunks may have differing lengths. The backend storage system may include a data array.

Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm. Dividing the portion of the data file into a plurality of file chunks may include dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file structure.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features and advantages will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic view of a storage system and a cache management process coupled to a distributed computing network;

FIG. **2** is a diagrammatic view of the storage system of FIG. **1**; and

FIG. **3** is a flow chart of one implementation of the cache management process of FIG. **1**.

Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

System Overview:

Referring to FIG. **1**, there is shown cache management process **10** that may reside on and may be executed by storage system **12**, which may be connected to network **14** (e.g., the Internet or a local area network). Examples of storage system **12** may include, but are not limited to: a Network Attached Storage (NAS) system, a Storage Area Network (SAN), a personal computer with a memory system, a server computer with a memory system, and a cloud-based device with a memory system.

As is known in the art, a SAN may include one or more of a personal computer, a server computer, a series of server computers, a mini computer, a mainframe computer, a RAID device and a NAS system. The various components of storage system **12** may execute one or more operating systems, examples of which may include but are not limited to: Microsoft Windows XP Server™; Novell Netware™; Redhat Linux™, Unix, or a custom operating system, for example.

The instruction sets and subroutines of cache management process **10**, which may be stored on storage device **16** included within storage system **12**, may be executed by one or more processors (not shown) and one or more memory architectures (not shown) included within storage system **12**. Storage device **16** may include but is not limited to: a hard disk drive; a tape drive; an optical drive; a RAID device; a random access memory (RAM); a read-only memory (ROM); and all forms of flash memory storage devices.

Network **14** may be connected to one or more secondary networks (e.g., network **18**), examples of which may include but are not limited to: a local area network; a wide area network; or an intranet, for example.

Various IO requests (e.g. IO request **20**) may be sent from client applications **22**, **24**, **26**, **28** to storage system **12**. Examples of IO request **20** may include but are not limited to data write requests (i.e. a request that content be written to storage system **12**) and data read requests (i.e. a request that content be read from storage system **12**).

The instruction sets and subroutines of client applications **22**, **24**, **26**, **28**, which may be stored on storage devices **30**, **32**, **34**, **36** (respectively) coupled to client electronic devices **38**, **40**, **42**, **44** (respectively), may be executed by one or more processors (not shown) and one or more memory architectures (not shown) incorporated into client electronic devices **38**, **40**, **42**, **44** (respectively). Storage devices **30**, **32**, **34**, **36** may include but are not limited to: hard disk drives; tape drives; optical drives; RAID devices; random access memories (RAM); read-only memories (ROM), and all forms of flash memory storage devices. Examples of client electronic devices **38**, **40**, **42**, **44** may include, but are not limited to, personal computer **38**, laptop computer **40**, personal digital assistant **42**, notebook computer **44**, a server (not shown), a data-enabled, cellular telephone (not shown), and a dedicated network device (not shown).

Users **46**, **48**, **50**, **52** may access storage system **12** directly through network **14** or through secondary network **18**. Further, storage system **12** may be connected to network **14** through secondary network **18**, as illustrated with link line **54**.

The various client electronic devices may be directly or indirectly coupled to network **14** (or network **18**). For example, personal computer **38** is shown directly coupled to network **14** via a hardwired network connection. Further, notebook computer **44** is shown directly coupled to network **18** via a hardwired network connection. Laptop computer **40** is shown wirelessly coupled to network **14** via wireless communication channel **56** established between laptop computer **40** and wireless access point (i.e., WAP) **58**, which is shown directly coupled to network **14**. WAP **58** may be, for example, an IEEE 802.11a, 802.11b, 802.11g, 802.11n, Wi-Fi, and/or Bluetooth device that is capable of establishing wireless communication channel **56** between laptop computer **40** and WAP **58**. Personal digital assistant **42** is shown wirelessly coupled to network **14** via wireless communication channel **60** established between personal digital assistant **42** and cellular network/bridge **62**, which is shown directly coupled to network **14**.

Client electronic devices **38**, **40**, **42**, **44** may each execute an operating system, examples of which may include but are not limited to Microsoft Windows™, Microsoft Windows CE™, Redhat Linux™, or a custom operating system.

For illustrative purposes, storage system **12** will be described as being a network-based storage system that includes a plurality of electro-mechanical backend storage devices. However, this is for illustrative purposes only and is not intended to be a limitation of this disclosure, as other configurations are possible and are considered to be within the scope of this disclosure. For example and as discussed above, storage system **12** may be a personal computer that includes a single electro-mechanical storage device.

Referring also to FIG. **2**, storage system **12** may include a server computer/controller (e.g. server computer/controller **100**) and a plurality of storage targets T_{1-n} (e.g. storage targets **102**, **104**, **106**, **108**). Storage targets **102**, **104**, **106**, **108** may be configured to provide various levels of performance and/or high availability. For example, one or more of storage targets **102**, **104**, **106**, **108** may be configured as a RAID 0 array, in which data is striped across storage targets. By striping data across a plurality of storage targets, improved performance may be realized. However, RAID 0 arrays do not provide a level of high availability. Accordingly, one or more of storage targets **102**, **104**, **106**, **108** may be configured as a RAID 1 array, in which data is mirrored between storage targets. By minoring data between storage targets, a level of high availability is achieved as multiple copies of the data are stored within storage system **12**.

While storage targets **102**, **104**, **106**, **108** are discussed above as being configured in a RAID 0 or RAID 1 array, this is for illustrative purposes only and is not intended to be a limitation of this disclosure, as other configurations are possible. For example, storage targets **102**, **104**, **106**, **108** may be configured as a RAID 3, RAID 4, RAID 5 or RAID 6 array.

While in this particular example, storage system **12** is shown to include four storage targets (e.g. storage targets **102**, **104**, **106**, **108**), this is for illustrative purposes only and is not intended to be a limitation of this disclosure. Specifically, the actual number of storage targets may be increased or decreased depending upon e.g. the level of redundancy/performance/capacity required.

Storage system **12** may also include one or more coded targets **110**. As is known in the art, a coded target may be used to store coded data that may allow for the regeneration of data lost/corrupted on one or more of storage targets **102**, **104**, **106**, **108**. An example of such a coded target may include but is not limited to a hard disk drive that is used to store parity data within a RAID array.

While in this particular example, storage system **12** is shown to include one coded target (e.g., coded target **110**), this is for illustrative purposes only and is not intended to be a limitation of this disclosure. Specifically, the actual number of coded targets may be increased or decreased depending upon e.g. the level of redundancy/performance/capacity required.

Examples of storage targets **102**, **104**, **106**, **108** and coded target **110** may include one or more electro-mechanical hard disk drives, wherein a combination of storage targets **102**, **104**, **106**, **108** and coded target **110** may form non-volatile, electro-mechanical memory system **112**.

The manner in which storage system **12** is implemented may vary depending upon e.g. the level of redundancy/performance/capacity required. For example, storage system **12** may be a RAID device in which server computer/controller **100** is a RAID controller card and storage targets **102**, **104**, **106**, **108** and/or coded target **110** are individual "hot-swappable" hard disk drives. An example of such a RAID device may include but is not limited to an NAS device. Alternatively, storage system **12** may be configured as a SAN, in which server computer/controller **100** may be e.g., a server computer and each of storage targets **102**, **104**, **106**, **108** and/or coded target **110** may be a RAID device and/or computer-based hard disk drive. Further still, one or more of storage targets **102**, **104**, **106**, **108** and/or coded target **110** may be a SAN.

In the event that storage system **12** is configured as a SAN, the various components of storage system **12** (e.g. server computer/controller **100**, storage targets **102**, **104**, **106**, **108**, and coded target **110**) may be coupled using network infrastructure **114**, examples of which may include but are not limited to an Ethernet (e.g., Layer **2** or Layer **3**) network, a fiber channel network, an InfiniBand network, or any other circuit switched/packet switched network.

Storage system **12** may execute all or a portion of cache management process **10**. The instruction sets and subroutines of cache management process **10**, which may be stored on a storage device (e.g., storage device **16**) coupled to server computer/controller **100**, may be executed by one or more processors (not shown) and one or more memory architectures (not shown) included within server computer/controller **100**. Storage device **16** may include but is not limited to: a hard disk drive; a tape drive; an optical drive; a RAID device; a random access memory (RAM); a read-only memory (ROM); and all forms of flash memory storage devices.

As discussed above, various IO requests (e.g. IO request **20**) may be generated. For example, these IO requests may be sent from client applications **22**, **24**, **26**, **28** to storage system **12**. Additionally/alternatively and when server computer/controller **100** is configured as an application server, these IO requests may be internally generated within server computer/controller **100**. Examples of IO request **20** may include but are not limited to data write request **116** (i.e. a request that content **118** be written to storage system **12**) and data read request **120** (i.e. a request that content **118** be read from storage system **12**).

Server computer/controller **100** may include input-output logic **122** (e.g., a network interface card or a Host Bus Adaptor (HBA)), processing logic **124**, and first cache system **126**. Examples of first cache system **126** may include but are not limited to a volatile, solid-state, cache memory system (e.g., a dynamic RAM cache memory system) and/or a non-volatile, solid-state, cache memory system (e.g., a flash-based, cache memory system).

During operation of server computer/controller **100**, content **118** to be written to storage system **12** may be received by input-output logic **122** (e.g. from network **14** and/or network **18**) and processed by processing logic **124**. Additionally/alternatively and when server computer/controller **100** is configured as an application server, content **118** to be written to storage system **12** may be internally generated by server computer/controller **100**. As will be discussed below in greater detail, processing logic **124** may initially store content **118** within first cache system **126**.

Depending on the manner in which first cache system **126** is configured, processing logic **124** may immediately write content **118** to second cache system **128**/non-volatile, electro-mechanical memory system **112** (if first cache system **126** is configured as a write-through cache) or may subsequently write content **118** to second cache system **128**/non-volatile, electro-mechanical memory system **112** (if first cache system **126** is configured as a write-back cache). Additionally and in certain configurations, processing logic **124** may calculate and store coded data on coded target **110** (included within non-volatile, electromechanical memory system **112**) that may allow for the regeneration of data lost/corrupted on one or more of storage targets **102**, **104**, **106**, **108**. For example, if processing logic **124** was included within a RAID controller card or an NAS/SAN controller, processing logic **124** may calculate and store coded data on coded target **110**. However, if processing logic **124** was included within e.g., an applications server, data array **130** may calculate and store coded data on coded target **110**.

Examples of second cache system **128** may include but are not limited to a volatile, solid-state, cache memory system (e.g., a dynamic RAM cache memory system) and/or a non-volatile, solid-state, cache memory system (e.g., a flash-based, cache memory system).

The combination of second cache system **128** and non-volatile, electromechanical memory system **112** may form data array **130**, wherein first cache system **126** may be sized so that the number of times that data array **130** is accessed may be reduced. Accordingly, by sizing first cache system **126** so that first cache system **126** retains a quantity of data sufficient to satisfy a significant quantity of IO requests (e.g., IO request **20**), the overall performance of storage system **12** may be enhanced.

Further, second cache system **128** within data array **130** may be sized so that the number of times that non-volatile, electromechanical memory system **112** is accessed may be reduced. Accordingly, by sizing second cache system **128** so that second cache system **128** retains a quantity of data sufficient to satisfy a significant quantity of IO requests (e.g., IO request **20**), the overall performance of storage system **12** may be enhanced.

As discussed above, the instruction sets and subroutines of cache management process **10**, which may be stored on storage device **16** included within storage system **12**, may be executed by one or more processors (not shown) and one or more memory architectures (not shown) included within storage system **12**. Accordingly, in addition to being executed on server computer/controller **100**, some or all of the instruction sets and subroutines of cache management process **10** may be executed by one or more processors (not shown) and one or more memory architectures (not shown) included within data array **130**.

The Cache Management Process:

As discussed above, various IO requests may be processed by server computer/controller **100**, examples of which may include but are not limited to data write request **116** (i.e. a request that content **118** be written to storage system **12**) and data read request **120** (i.e. a request that content **118** be read from storage system **12**). Assume for illustrative proposes that content **118** is a considerably large file that resides within data array **130**. Examples of such a large file may include but are not limited to a shared database file. Accordingly, when a read request is received concerning content **118** (which, as discussed, is resident on data array **130**), only a small portion of content **118** may be retrieved and cached in response to

such a read request (as it would be impractical/undesirable/unneeded to retrieve and cache content **118** in its entirety.

Assume for illustrative purposes that server computer/controller **100** receives such a read request **120** concerning only a portion of content **118** (e.g., portion **132** of content **118**) currently stored on a backend storage system (e.g., data array **130**). Cache management process **10** may process **200** (on the host e.g., server computer/controller **100**) read request **120**.

While content **118** is described above as a larger file and, therefore, read request **120** concerns only a portion of content **118**, this is for illustrative purposes only and is not intended to be a limitation of this disclosure, as other configurations are possible and are considered to be within the scope of this disclosure and the claims. For example, in the event that content **118** is a smaller file, the portion requested in read request **120** may be the entire file (e.g., all of content **118**), as opposed to a smaller amount).

Upon processing read request **120**, cache management process **10** may obtain **202** portion **132** of the data file (e.g., content **118**) from the backend storage system (e.g., data array **130**) and may divide **204** portion **132** of content **118** into plurality of file chunks **134**. For example, if portion **132** was a 128 kb portion of content **118**, portion **132** may be divided **204** into thirty-two 4 kb chunks.

When dividing **204** portion **132** of content **118** into plurality of chunks **134**, logic may be applied to increase the probability of commonality amongst chunks. Therefore, portion **132** may be divided **204** in accordance with the format/type of content **118**. For example, text files may be divided **204** in accordance with a sticky bit algorithm.

A sticky bit algorithm is an algorithm that calculates a hash value for short sequences of data. For instance, if there is a data chunk of 100 KB, the sticky bit algorithm may calculate the hash value for every ten consecutive bytes of the data chunk and may identify a cut point (if the hash value modulo some constant is zero). For instance, if the hash value modulo 4,096 is 0, this assures that the file will be cut to portions that are roughly 4,096 bytes in length. If there is a large chunk with no cut point (e.g., a 40 KB chunk with no cut point), a cut point may be added artificially. This may happen e.g., if all the data is constant. The sticky bit algorithm may assure that if only a few bytes of data are added in the middle of a file, most chunks of the file will remain the same.

Additionally, video files may be divided **204** into video frames. Further, document files may be divided **204** based upon components (e.g., still images and text-based components). Accordingly, plurality of file chunks **134** may all have a common length or may have differing lengths (depending upon the manner in which they are divided).

Cache management process **10** may compare **206** each of plurality of file chunks **132** to other file chunks stored within a frontend cache system (e.g., first cache system **126**) associated with the host (e.g., server computer/controller **100**) to identify the unique file chunks within plurality of file chunks **132**. A unique file chunk may be classified as a file chunk that is included within plurality of file chunks **132** that is not identical to any other file chunk already stored within first cache system **126**. Once comparison **206** is performed and one or more unique file chunks are identified, cache management process **10** may store **208** the unique file chunks within first cache system **126**.

When comparing **206** each of plurality of file chunks **132** to other file chunks already stored within first cache system **126**, cache management process **10** may identify **210** non-unique file chunks within plurality of file chunks **132**. A non-unique file chunk may be classified as a file chunk that is included within plurality of file chunks **132** that is identical to another file chunk already stored within first cache system **126**. Once the non-unique file chunks are identified **210**, cache management process **10** may not store **212** the non-unique file chunks within first cache system **126** (and/or delete the non-unique file chunks from their temporary storage location).

Accordingly, through the use of cache management process **10**, only a single copy of a file chunk will be stored within first cache system **126**. Accordingly, assume for illustrative purposes that four different files (or file portions) are currently stored within first cache system **126** due to the processing of four different read requests. Further, assume that read request **120** is received by e.g., server computer/controller **100** requesting portion **132** of content **118**. Accordingly, cache management process **10** may process **200** read request **120**; may obtain **202** portion **132** of content **118** from data array **130**; and may divide **204** portion **132** of content **118** into plurality of file chunks **134**, where the division algorithm is dependent on the file type.

As discussed above, cache management process **10** may compare **206** each of plurality of file chunks **132** to other file chunks already stored within first cache system **126** (namely the file chunks of the above-described four different files/file portions) to identify the unique file chunks included within plurality of file chunks **132**. Assume for illustrative purposes that cache management process **10** divides **204** portion **132** into ten file chunks, namely file chunks **136**, **138**, **140**, **142**, **144**, **146**, **148**, **150**, **152**, **154**. Further assume for illustrative purposes that when comparing **206** each of plurality of file chunks **132** to other file chunks already stored within first cache system **126**, cache management process **10** determines that only six file chunks (namely file chunks **136**, **138**, **140**, **146**, **150**, **152**) are unique (and may be stored **208** within first cache system **126**) and that four file chunks (namely file chunks **142**, **144**, **148**, **154**) are not unique (and may not be stored **212** within first cache system **126**). For the file chunks that are not unique (namely file chunks **142**, **144**, **148**, **154**) and, therefore, are not stored **212** within first cache system **126**, the cache directory (not shown) associated with first cache system **126** may simply map the cache directory entry that is associated with each of the four non-stored file chunks to the file chunk included within first cache system **126** that is identical to each of the four non-stored file chunks.

General:

As will be appreciated by one skilled in the art, the present disclosure may be embodied as a method, a system, or a computer program product. Accordingly, the present disclosure may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, the present disclosure may take the form of a computer program product on a computer-usable storage medium having computer-usable program code embodied in the medium.

Any suitable computer usable or computer readable medium may be utilized. The computer-usable or computer-readable medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a non-exhaustive list) of the computer-readable medium may include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-

ROM), an optical storage device, a transmission media such as those supporting the Internet or an intranet, or a magnetic storage device. The computer-usable or computer-readable medium may also be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning of the paper or other medium, then compiled, interpreted, or otherwise processed in a suitable manner, if necessary, and then stored in a computer memory. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The computer-usable medium may include a propagated data signal with the computer-usable program code embodied therewith, either in baseband or as part of a carrier wave. The computer usable program code may be transmitted using any appropriate medium, including but not limited to the Internet, wireline, optical fiber cable, RF, etc.

Computer program code for carrying out operations of the present disclosure may be written in an object oriented programming language such as Java, Smalltalk, C++ or the like. However, the computer program code for carrying out operations of the present disclosure may also be written in conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through a local area network/a wide area network/the Internet (e.g., network **14**).

The present disclosure is described with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, may be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer/special purpose computer/other programmable data processing apparatus, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer-readable memory that may direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowcharts and block diagrams in the figures may illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustrations, and combinations of blocks in the block diagrams and/or flowchart illustrations, may be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The embodiment was chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

A number of implementations have been described. Having thus described the disclosure of the present application in detail and by reference to embodiments thereof, it will be apparent that modifications and variations are possible without departing from the scope of the disclosure defined in the appended claims.

What is claimed is:

1. A computer-implemented method comprising:

processing, on a host, a read request received from a client application separate from the host for a portion of a data file stored on a backend storage system, wherein the host is a server computer;

obtaining the portion of the data file from the backend storage system;

dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file type, wherein dividing the portion of the data file into a plurality of file chunks includes dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm, wherein the sticky bit algorithm is configured to calculate a hash value for a set amount of consecutive bytes of each data chunk, the sticky bit

algorithm being further configured to identify a cut point associated with each data chunk, wherein the cut point is artificially created if the hash value modulo a constant is not zero for each data chunk;

comparing each of the plurality of file chunks to other file chunks stored within a first cache system located within the host to identify unique file chunks within the plurality of file chunks; and

storing the unique file chunks within the first cache system.

2. The computer-implemented method of claim **1** wherein comparing each of the plurality of file chunks to other file chunks stored within the first cache system includes:

identifying non-unique file chunks within the plurality of file chunks.

3. The computer-implemented method of claim **2** further comprising:

not storing the non-unique file chunks within the first cache system.

4. The computer-implemented method of claim **1** wherein the portion of the data file is a complete data file.

5. The computer-implemented method of claim **1** wherein the plurality of file chunks have a common length and are aligned.

6. The computer-implemented method of claim **1** wherein the plurality of file chunks have differing lengths.

7. The computer-implemented method of claim **1** wherein the backend storage system includes a data array.

8. A computer program product residing on a non-transitory computer readable medium having a plurality of instructions stored thereon which, when executed by a processor, cause the processor to perform operations comprising:

processing, on a host, a read request received from a client application separate from the host for a portion of a data file stored on a backend storage system, wherein the host is a server computer;

obtaining the portion of the data file from the backend storage system;

dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file type, wherein dividing the portion of the data file into a plurality of file chunks includes dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm, wherein the sticky bit algorithm is configured to calculate a hash value for a set amount of consecutive bytes of each data chunk, the sticky bit algorithm being further configured to identify a cut point associated with each data chunk, wherein the cut point is artificially created if the hash value modulo a constant is not zero for each data chunk;

comparing each of the plurality of file chunks to other file chunks stored within a first cache system located within the host to identify unique file chunks within the plurality of file chunks; and

storing the unique file chunks within the first cache system.

9. The computer program product of claim **8** wherein the instructions for comparing each of the plurality of file chunks to other file chunks stored within the first cache system include instructions for:

identifying non-unique file chunks within the plurality of file chunks.

10. The computer program product of claim **9** further comprising instructions for:

not storing the non-unique file chunks within the first cache system.

11. The computer program product of claim **8** wherein the portion of the data file is a complete data file.

12. The computer program product of claim **8** wherein the plurality of file chunks have a common length and are aligned.

13. The computer program product of claim **8** wherein the plurality of file chunks have differing lengths.

14. The computer program product of claim **8** wherein the backend storage system includes a data array.

15. A computing system comprising:

at least one processor device; and

at least one memory architecture coupled with the at least one processor device;

wherein the at least one processor device is further configured to perform operations comprising;

processing, on a host, a read request received from a client application separate from the host for a portion of a data file stored on a backend storage system, wherein the host is a server computer;

obtaining the portion of the data file from the backend storage system;

dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a file type, wherein dividing the portion of the data file into a plurality of file chunks includes dividing the portion of the data file into a plurality of file chunks based, at least in part, upon a sticky bit algorithm, wherein the sticky bit algorithm is configured to calculate a hash value for a set amount of consecutive bytes of each data chunk, the sticky bit algorithm being further configured to identify a cut point associated with each data chunk, wherein the cut point is artificially created if the hash value modulo a constant is not zero for each data chunk;

comparing each of the plurality of file chunks to other file chunks stored within a first cache system located within the host to identify unique file chunks within the plurality of file chunks; and

storing the unique file chunks within the first cache system.

16. The computing system of claim **15** wherein comparing each of the plurality of file chunks to other file chunks stored within the first cache system includes:

identifying non-unique file chunks within the plurality of file chunks.

17. The computing system of claim **16** further configured to perform operations comprising:

not storing the non-unique file chunks within the first cache system.

18. The computing system of claim **15** wherein the portion of the data file is a complete data file.

19. The computing system of claim **15** wherein the plurality of file chunks have a common length and are aligned.

20. The computing system of claim **15** wherein the plurality of file chunks have differing lengths.

21. The computing system of claim **15** wherein the backend storage system includes a data array.

22. The computer-implemented method of claim **1** wherein the cut point is artificially created based, at least in part, upon an addition of one or more bytes in each data chunk.

23. The computer program product of claim **8** wherein the cut point is artificially created based, at least in part, upon an addition of one or more bytes in each data chunk.

24. The computing system of claim **15** wherein the cut point is artificially created based, at least in part, upon an addition of one or more bytes in each data chunk.

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